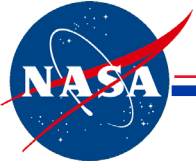


# **Assessing Hurricane Katrina Damage to the Mississippi Gulf Coast Using IKONOS Imagery**

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Rodney McKellip  
NASA Project Integration Office  
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JACIE Civil Commercial Imagery Evaluation Workshop  
Laurel, Maryland, USA  
March 14–16, 2006

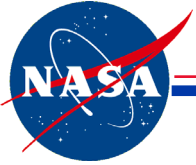


# Discussion Items

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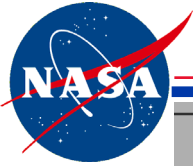
- Project Background
- Research Objectives
- Remote Sensing Data Acquisition and Processing Methods
- Results
- Concluding Remarks



# Project Background

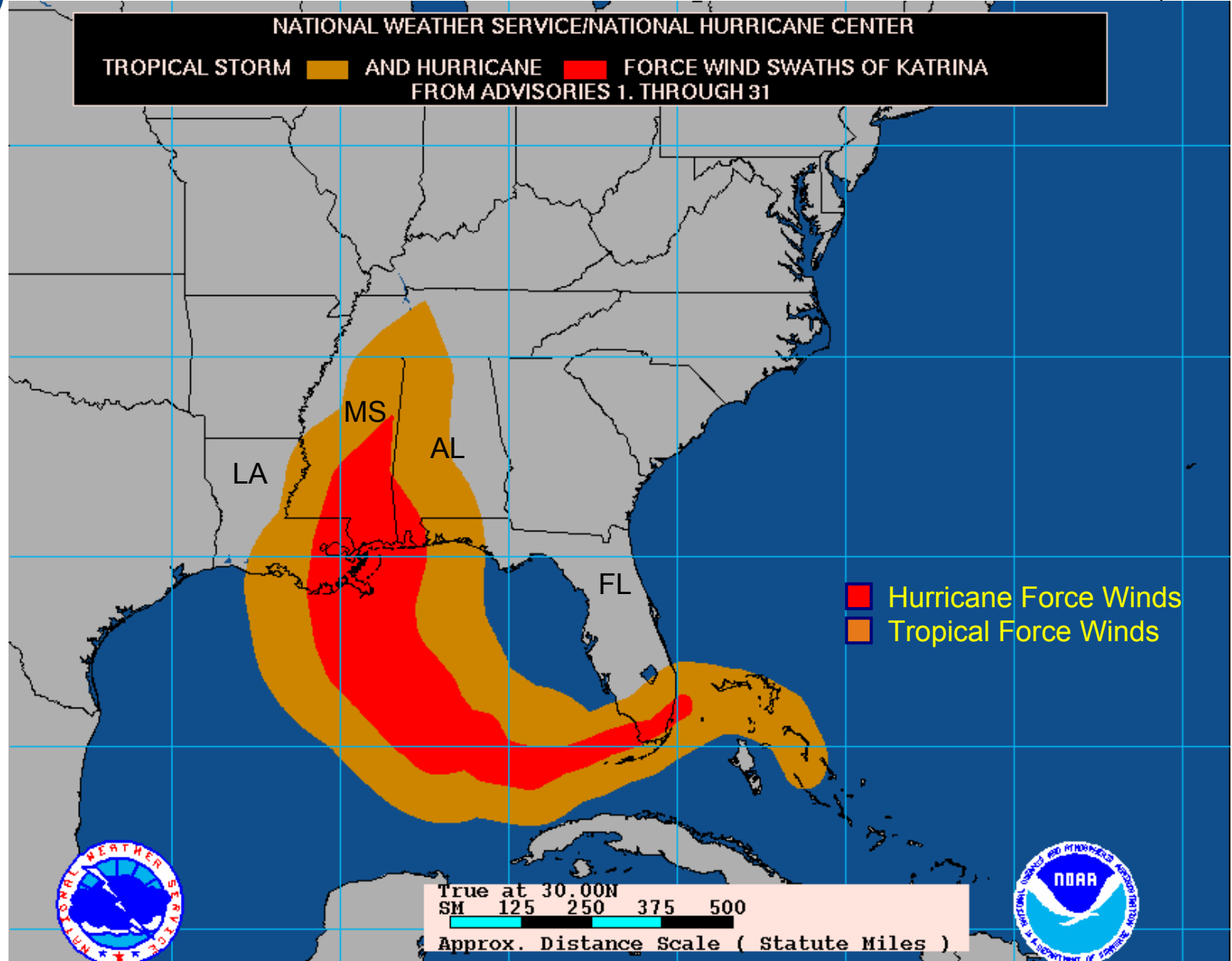
*Stennis Space Center*

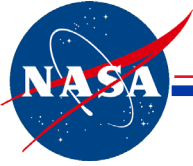
- Hurricane Katrina hit southwestern Mississippi on August 29, 2005, at 10 a.m. CDT as a category 3 event with storm surges up to ~9 m and sustained winds of ~120 mph
- The hurricane ravaged several coastal towns, destroying or severely damaging hundreds of homes
- Hurricane Katrina deposited millions of tons of debris and caused severe damage to coastal forests
- In response, several Federal agencies have been using a broad range of remotely sensed data to aid damage assessment and disaster recovery efforts
- IKONOS imagery is being used for Hurricane Katrina damage assessment along the Mississippi Gulf Coast; this presentation focuses on the use of IKONOS data collected over southwestern coastal Mississippi on September 2, 2005



# Hurricane Katrina's Swath

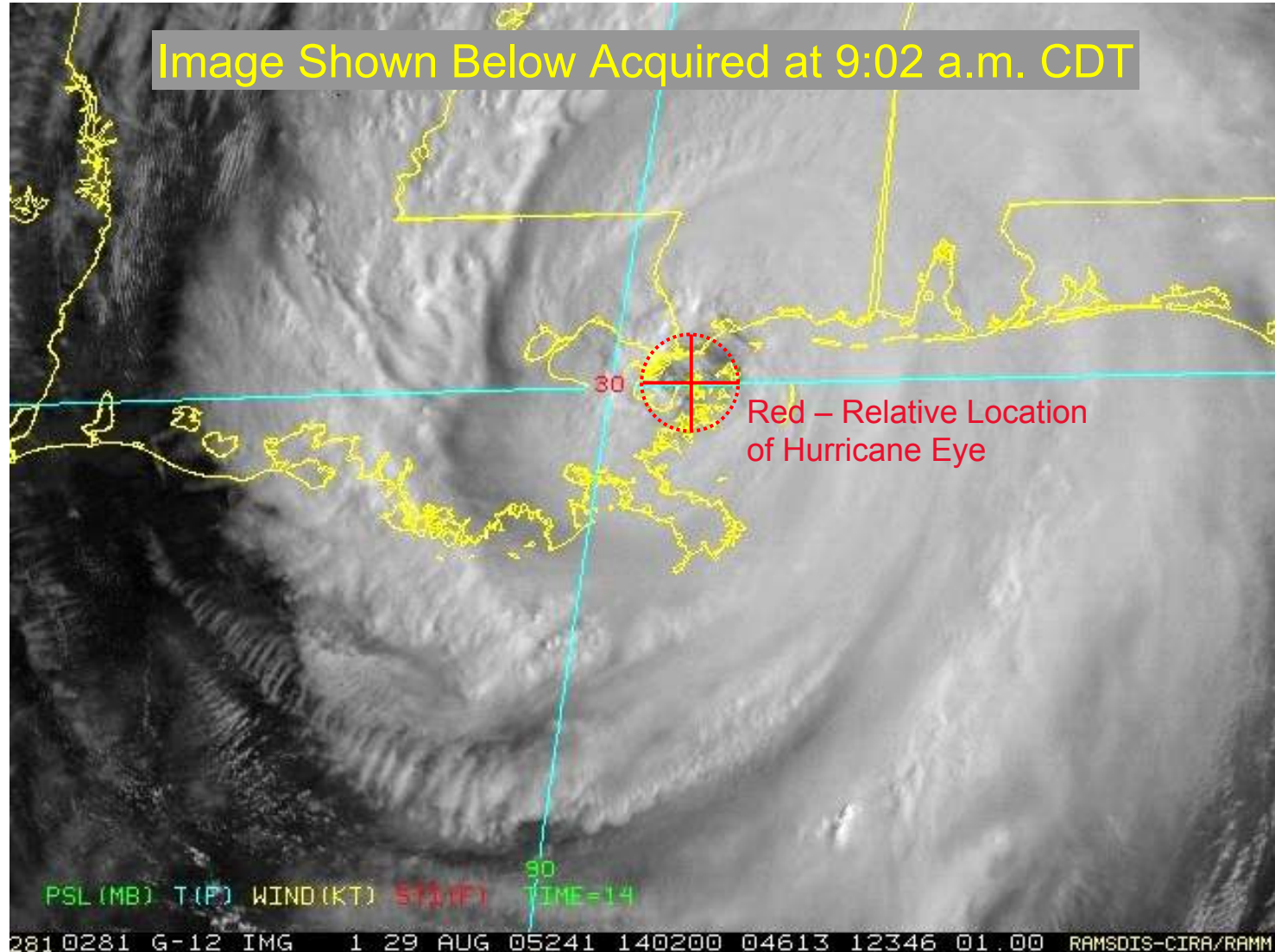
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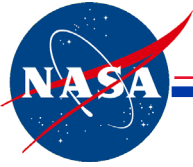


# Katrina's Approach of Mississippi Shown on GOES-12 Satellite Imagery

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# Location of Study Area in Southwestern Mississippi Gulf Coast

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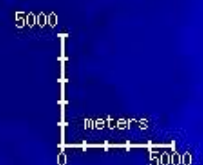


IKONOS Data  
Acquired 9/2/2005

Pass  
Christian

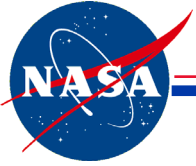
Waveland and  
Bay St. Louis

Landsat 7 Mosaic from NASA Scientific Data Purchase in Background



Includes material © Space Imaging LLC





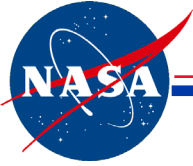
# IKONOS Data Used in Study

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IKONOS Color Composite – Bands 4,3,1 Loaded into RGB



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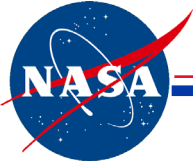


# Federal Efforts to Assess Katrina Damage with IKONOS Data

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- Several Federal agencies have been using IKONOS and other commercial remote sensing data for assessing damage from Hurricane Katrina, including NOAA, USGS, NASA, NGA, and FEMA
  - NOAA Coastal Services Center (CSC) used IKONOS data and Feature Analyst software for mapping storm debris in Gulfport, MS
  - DHS/NGA/FEMA used heads-up digitizing to map debris zones apparent on high resolution satellite (e.g., IKONOS) and aerial data
  - The USGS, NOAA, FEMA, and others are using mid- to high-resolution remote sensing data to map and assess flood extent, coastal land loss, and vegetation condition; IKONOS imagery is being used to support these efforts

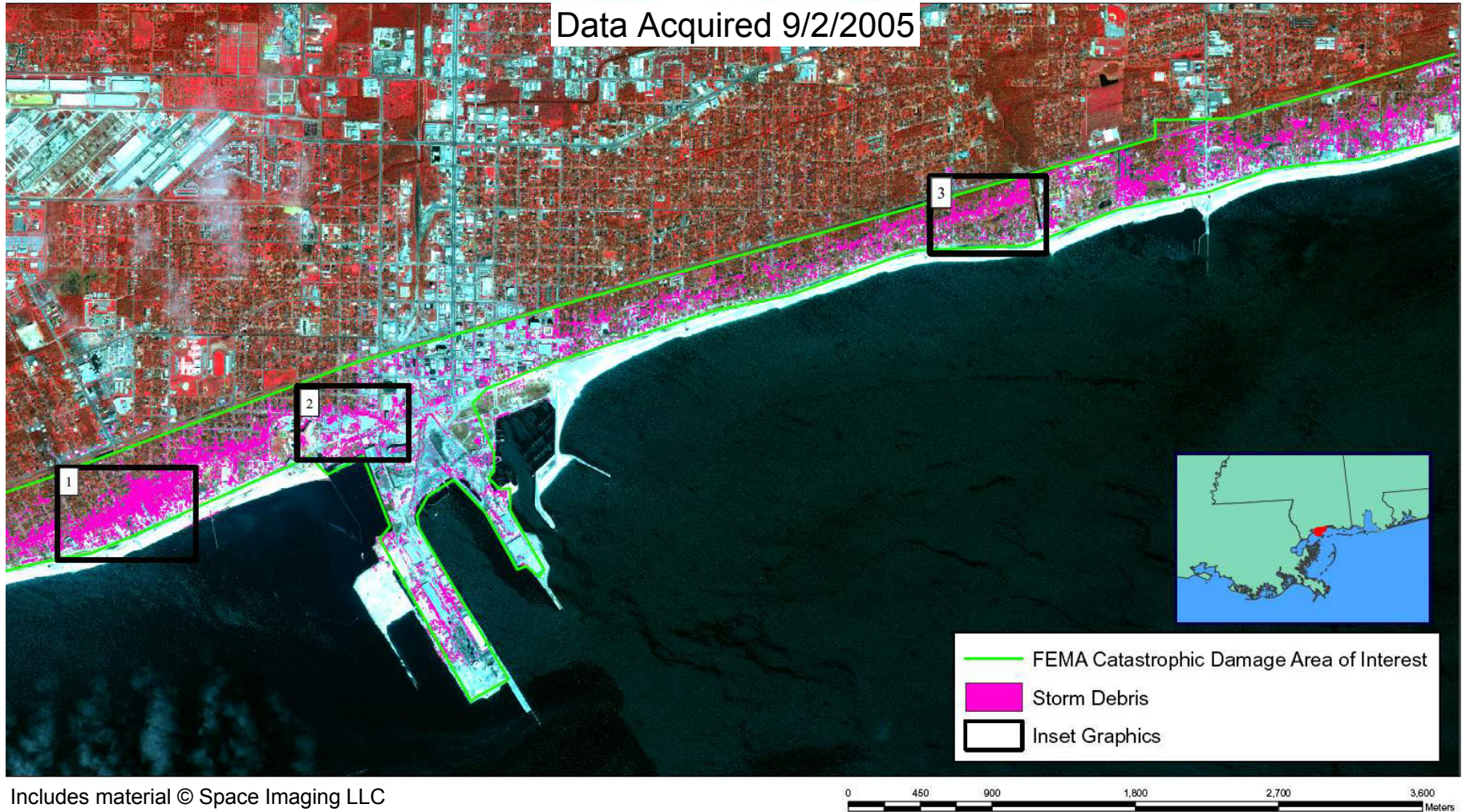


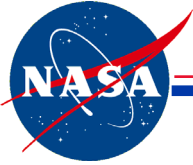


# Example Debris Map from IKONOS Data

## Source: NOAA Coastal Services Center

Stennis Space Center



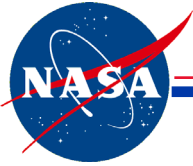


# Objectives of Study

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- Assess pan-sharpened multispectral IKONOS data for visualization of Hurricane Katrina storm damage
  - Damaged buildings, wood-dominated debris, denuded forest, and mud covered open areas
- Assess traditional image classification techniques for classifying storm damage types from pan-sharpened IKONOS data
  - ISODATA unsupervised clustering and/or Maximum Likelihood supervised classification
- Longer term: Assess hurricane damage using change detection techniques in conjunction with before and after storm IKONOS data
  - Damage to residential and industrial areas, forests, and marsh land





# Hurricane Damage in Waveland, Mississippi

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Saint Clare's Catholic Church  
Looking North from Coast



House and Forest Damage  
1.2 km from Waveland Coast

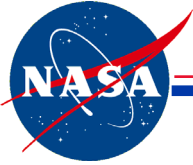


Waveland Coast - East View  
from Saint Clare's Church



Tree Damage at Former Home  
0.4 km from Waveland Coast





# Preparing IKONOS Data for Classification

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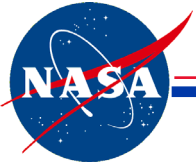
- Acquired IKONOS data from a USGS Katrina Web site in GeoTIFF format
- Stacked visible and NIR multispectral band tiffs into multiband image
- Applied “bootstrap” haze correction to individual bands as needed
  - Used minimum value subtract technique (Jensen, 1996)
- Ran pan-sharpening algorithm to produce 1-meter pan-sharpened multispectral image
  - Used Local Mean and Variance Matching (LMVM) filtering technique described by de Béthune et al. (1998), as implemented in ERDAS IMAGINE® via the Spatial Modeler toolbox
- Developed and applied appropriate look-up table stretch to visually enhance storm damage features of interest

## Sources:

de Béthune, S., F. Muller, and J.-P. Donnay, 1998. Fusion of multispectral and panchromatic images by local mean and variance matching filtering techniques. Proceedings of the Second International Conference: Fusion of Earth Data: Merging Point Measurements, Raster Maps and Remotely Sensed Images. Sophia Antipolis, France, 28–30 January, (Thierry Ranchin and Lucien Wald, eds. published by SEE/URISCA, Nice, France), pp. 31–36.

Jensen, J.R., 1996. Introductory Digital Image Processing: A Remote Sensing Perspective. 2<sup>nd</sup> ed. Upper Saddle River, New Jersey: Prentice Hall.

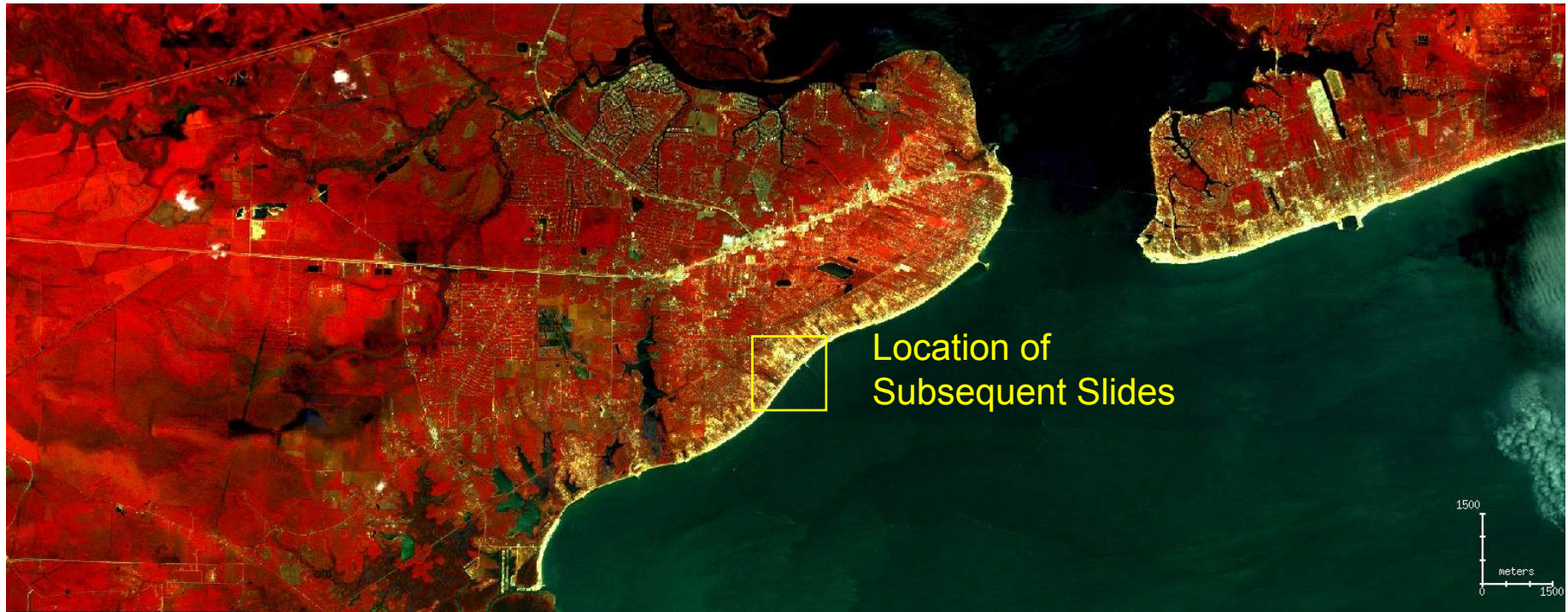




# IKONOS Data Used in Study

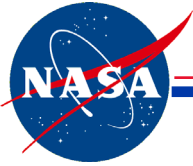
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IKONOS Color Composite – Bands 4,3,1 Loaded into RGB



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# IKONOS Panchromatic Data – 9/2/2006

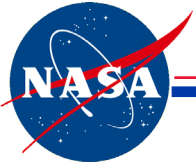
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## Zooms of Waveland, MS



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# IKONOS Multispectral Data – 9/2/2006

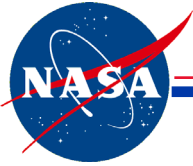
Stennis Space Center

## Zooms of Waveland, MS



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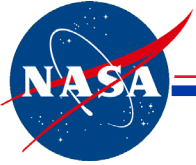
# IKONOS Pan-Sharpened Multispectral Data – 9/2/2006

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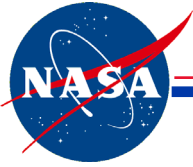




# IKONOS Image Classification

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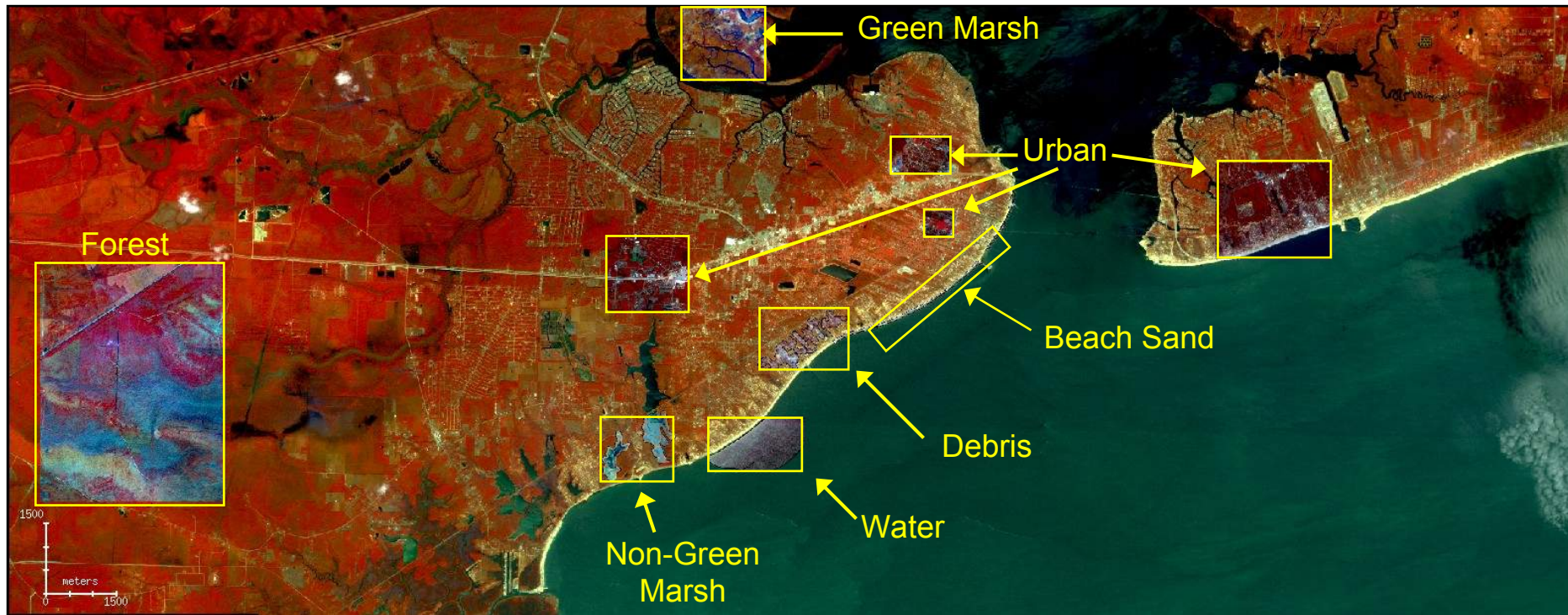
- Ran series of ISODATA unsupervised classifications to collect signatures needed for supervised classification
- Appended signatures from 10 individual unsupervised classifications into master signature file
- Subjected master signature file of 191 cluster classes and pan-sharpened data to supervised classification with the maximum likelihood (ML) algorithm
- Applied contrast-enhanced color table to classification results to resemble an enhanced 431 RGB composite of the pan-sharpened data
- Evaluated preliminary results of ML classification, refining as needed to produce final classification product
- Assessed final classification compared to reference data



# Selection of Training Areas for Collecting Classification Signatures

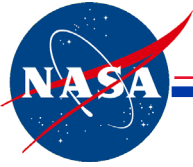
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Independent Unsupervised Classifications were Produced for 10 Subset Areas



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# Example IKONOS Classification Results vs. Bands 4,3,1 RGB Color Composite

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ML Classification – Pseudo Color LUT

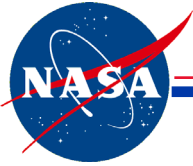


IKONOS 4,3,1 RGB



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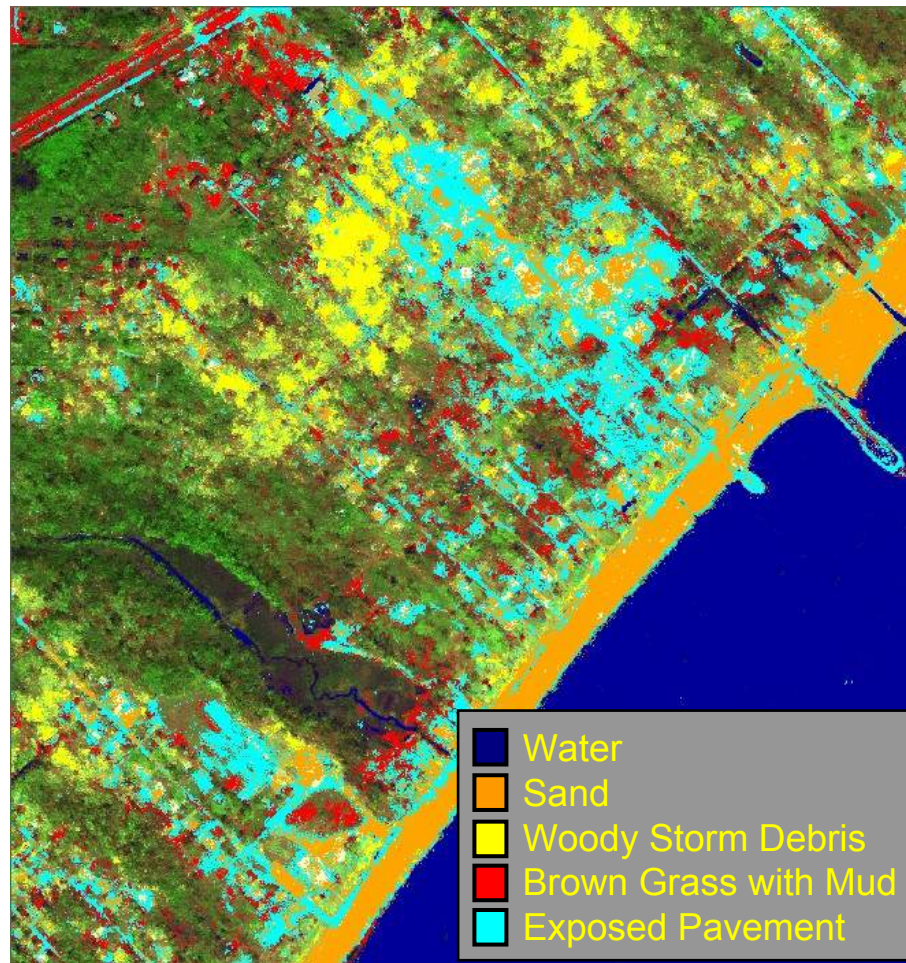




# Select IKONOS Classification Results vs. Bands 4,3,1 RGB Color Composite

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ML Classification – Select Classes Colored

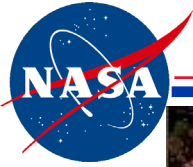


IKONOS 4,3,1 RGB



Includes material © Space Imaging LLC





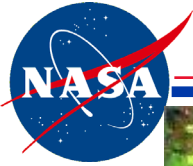
# NOAA 0.5-Meter Digital Aerial Imagery

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Data Acquired 8/30/2005 Before Road Clearing

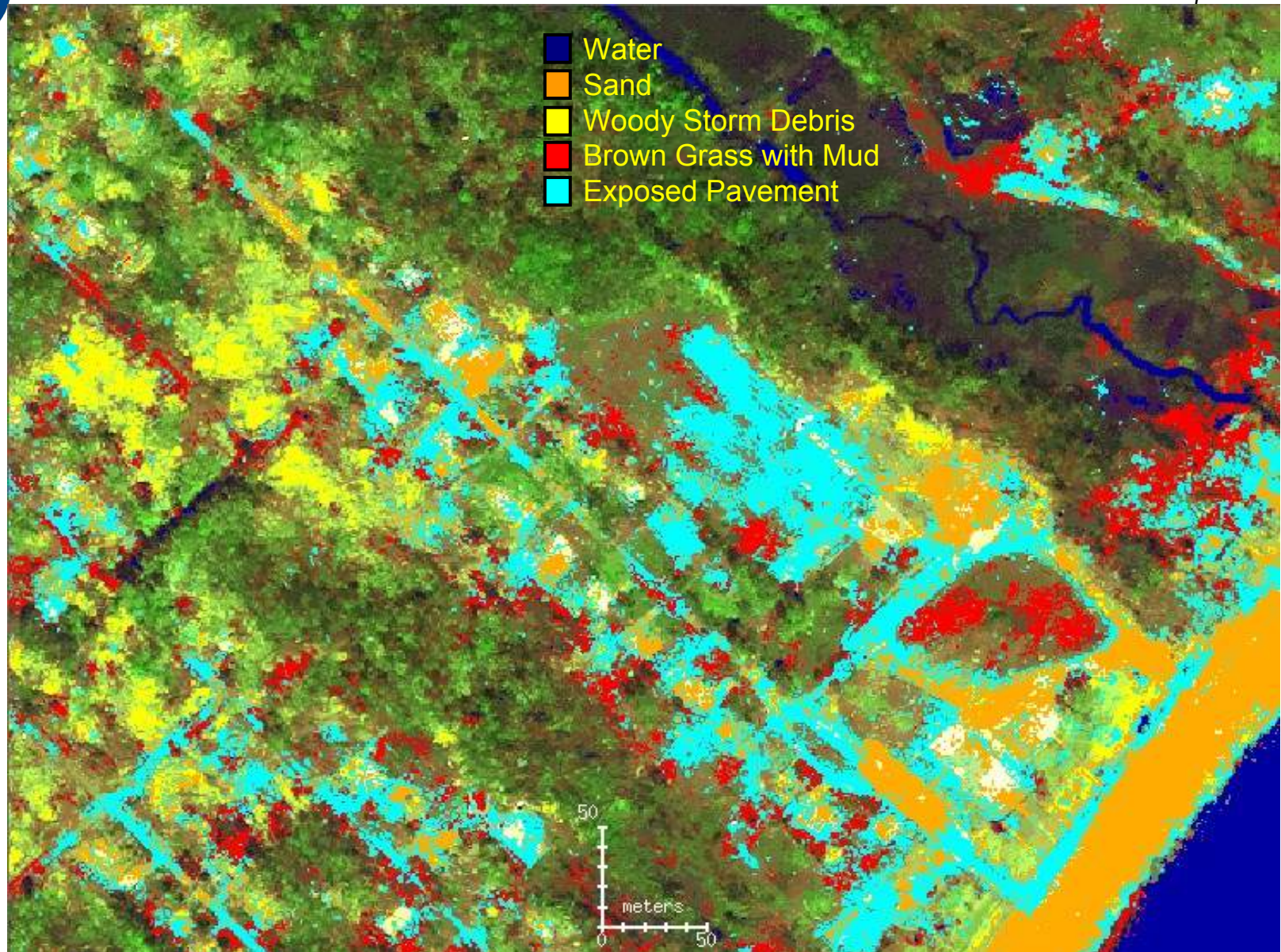




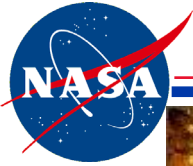


# IKONOS Classification Result

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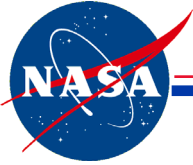




# IKONOS Data Acquired 9/2/2005

Stennis Space Center



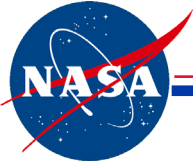


# Visualization of Hurricane Damage on the IKONOS RGBs

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- Several flood and wind damage effects can be viewed on IKONOS RGBs, including forest foliage loss and necrosis, multi-tree blow downs, flood water, house damage, house loss, flood-deposited mud on grass, grass dieback, and debris in coastal water.
- Deciduous forests were largely defoliated by the storm, whereas the pine-dominated evergreens were green although greatly reduced by storm damage. The 1-meter spatial resolution was insufficient to show single-tree blow down on a consistent basis, although mass tree blow downs were evident in some cases.
- Flooded, defoliated wetland forests and marshes can be clearly seen.
- Several marsh conditions were evident, apparently because of variability in greenness and saltwater conditions.
- Mud-covered surfaces were evident, consisting primarily of mud on lawns, although mud on paved surfaces was also evident.
- The September 2nd acquisition date of the IKONOS data was close in time to the hurricane's landfall and does not necessarily show vegetation stress effects that take a longer period to be manifested.

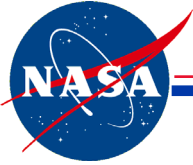




# **“Traditional” Classification of Storm Damage from Pan-Sharpended IKONOS Data**

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- Woody storm debris was classified for open areas but was not classified in areas obscured by sufficiently dense forest. Some classification commission error was also noted for this storm damage type.
- The classification of woody storm debris was realized without having to resort to sub-pixel or contextual supervised classification software and techniques.
- Effective wall-to-wall land use/land cover classification was not achieved, in part because of time constraints in evaluating and refining classification results.
- Some confusion was noted between pavement, roofing, and mud-covered surfaces. Concrete and bright roof types were also confused. Forest cluster classes were difficult to categorize, in part because of storm defoliation effects.
- The classification process demonstrated here requires trial and error processing, which is not unusual for supervised classification of targeted surface cover types.
- The pan-sharpened output was similar to the input multispectral image yet retained the texture of the 1-meter panchromatic image. This output enabled targeted ground features to be visualized and classified at the 1-meter scale.
- More work is needed to quantify accuracy of storm damage types as well as land use/land cover types from the IKONOS pan-sharpened multispectral data.



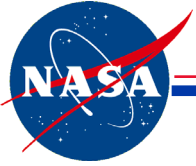
# Final Remarks

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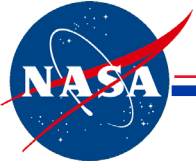
- Future work will involve use of multitemporal IKONOS and Landsat data for understanding MODIS change detection results in monitoring vegetation damage and recovery from Hurricane Katrina

*Participation in this work by Science Systems and Applications, Inc., was supported by NASA at the John C. Stennis Space Center, Mississippi, under Task Order NNS04AB54T.*





# Extra Slides

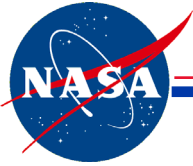


# Efforts to Assess Katrina's Forest Damage

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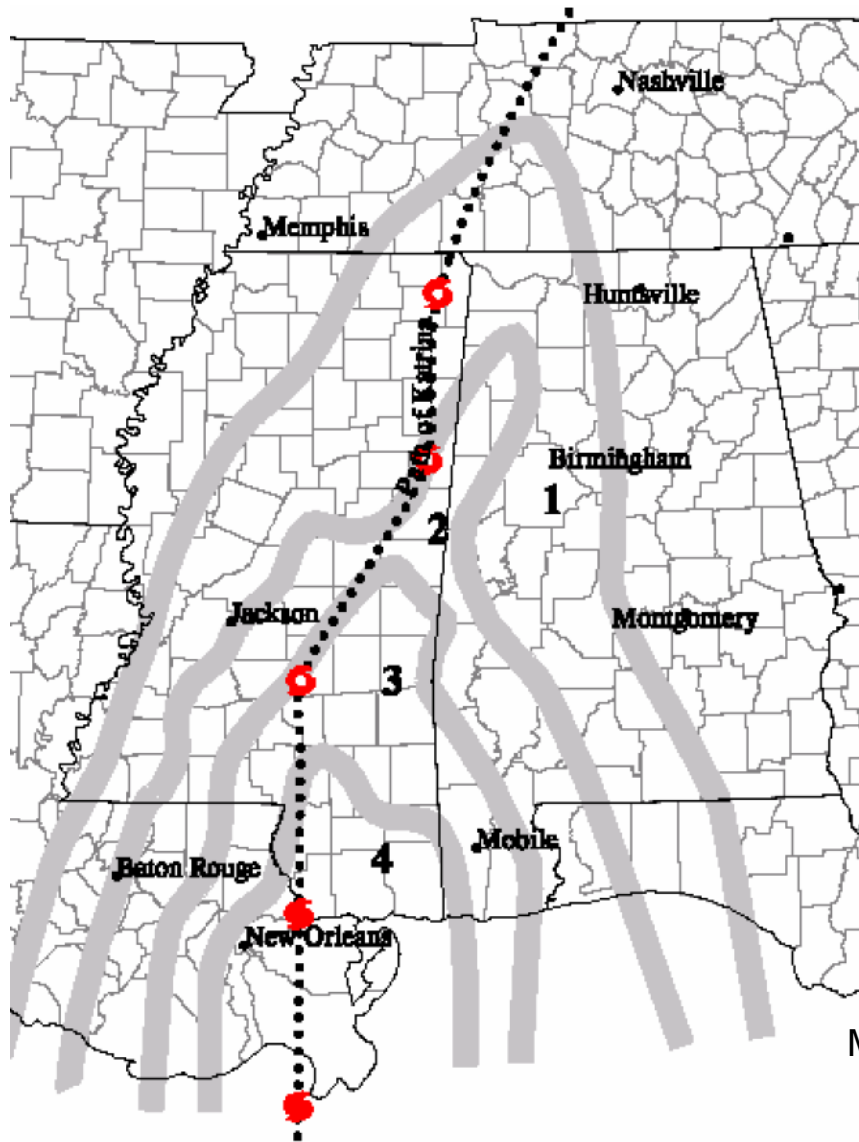
- The U.S. Forest Service is assessing Katrina forest damage and recovery in part via the Healthy Forests Initiative (<http://www.healthyforests.gov/>)
  - Assessments of forest damage as well as forest health due to post-storm insect outbreaks, diseases, and wildfire
- NASA is aiding the Federal effort to assess forest damage impacts from Hurricane Katrina, initially via analysis of multi-temporal MODIS data for monitoring forest vegetation greenness and moisture indicators
  - This effort uses multi-temporal Landsat and IKONOS data as reference data to aid analysis of MODIS-based change detection





# Preliminary Map of Katrina Forest Damage

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- 1 = Scattered, Light
- 2 = Light
- 3 = Moderate
- 4 = Severe

-  Hurricane Force Winds
-  Tropical Storm Winds

Map Source: USFS Forest Inventory and Analysis  
<http://www.srs.fs.usda.gov/katrina/>

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
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				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Joseph Spruce (1) Rodney McKellip (2)				5d. PROJECT NUMBER SWR C15C-JC15-00	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
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9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Applied Research & Technology Project Office, Code PA30, John C. Stennis Space Center, MS 39529				10. SPONSORING/MONITOR'S ACRONYM(S)	
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12. DISTRIBUTION/AVAILABILITY STATEMENT Unclassified/Publicly available STI per NASA Form 1676					
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14. ABSTRACT Hurricane Katrina hit southeastern Louisiana and the Mississippi Gulf Coast as a Category 3 hurricane with storm surges as high as 9 m. Katrina devastated several coastal towns by destroying or severely damaging hundreds of homes. Several Federal agencies are assessing storm impacts and assisting recovery using high-spatial-resolution remotely sensed data from satellite and airborne platforms. High-quality IKONOS satellite imagery was collected on September 2, 2005, over southwestern Mississippi. Pan-sharpened IKONOS multispectral data and ERDAS IMAGINE® software were used to classify post-storm land cover for coastal Hancock and Harrison Counties. This classification included a storm debris category of interest to FEMA for disaster mitigation. The classification resulted from combining traditional unsupervised and supervised classification techniques. Higher spatial resolution aerial and handheld photography were used as reference data. Results suggest that traditional classification techniques and IKONOS data can map wood-dominated storm debris in open areas if relevant training areas are used to develop the unsupervised classification signatures. IKONOS data also enabled other hurricane damage assessment, such as flood-deposited mud on lawns and vegetation foliage loss from the storm. IKONOS data has also aided regional Katrina vegetation damage surveys from multiday Land Remote Sensing Satellite and Moderate Resolution Imaging Spectroradiometer data.					
15. SUBJECT TERMS Hurricane Katrina, IKONOS imagery, hurricane damage					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19b. NAME OF RESPONSIBLE PERSON
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